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ANTARCTIC ECOSYSTEM RESEARCH GROUP

La Jolla, California

Preliminary Results of 1989-1990 AMLR Cruise Discussed

Following the completion of the 1989-1990 Antarctic Marine Living Resources (AMLR) cruise, Drs. Rennie Holt and Roger Hewitt convened a post-cruise meeting with the cruise's primary investigators in early June. Each investigator presented his or her preliminary results and analyses at the meeting.

The 1989-1990 AMLR cruise included four successive surveys of the pelagic marine environment in a 100 x 100 mile study area centered on Elephant Island, Antarctica, during January and February 1990. Data were collected to describe the thermohaline structure, the distribution of phytoplankton biomass and primary productivity, the distribution and demography of krill, and the foraging patterns of krill predators.

Dr. Anthony Amos of the University of Texas at Austin headed up physical oceanography studies on the cruise and reported that a hydrographic front, north of Elephant Island and aligned southwest- to-northeast, persisted throughout the observation period. Dr. Osmund Holm-Hansen of Scripps Institution of Oceanography reported that a relatively high phytoplankton biomass and production persisted throughout the observation period, although these were lower to the north of the front and higher to the south of the front. A second front was observed by Amos at the eastern side of the study area and was tentatively identified as the western end of the Weddell-Scotia Confluence.

Dr. Michael Macaulay of the University of Washington conducted hydroacoustic studies of krill (*Euphausia superba*) during the cruise. He found that krill abundance increased approximately 5- fold over the 2 month period, with highest concentrations north of Elephant Island and apparent immigration from east of the study area. Drs. Valerie Loeb of the Moss Landing Marine Laboratories and John Wormuth of Texas A & M University conducted direct krill sampling on the cruise. They reported that krill sampled throughout the observation period were reproductively mature, that mean body size increased (41.8 mm in January to 44.3 mm in February), and that there was a general transition from reproductively active to gravid and spent individuals. A second size mode of small, reproductively mature females and immature males were sampled in January and were associated with an apparent inflow of water from southeast of the study area. This size mode was not evident in February.

Dr. John Bengtson headed up a field team in foraging studies of krill predators on Seal Island, a small island off the coast of Elephant Island. Seal Island studies revealed that krill constituted 99% of the diet of chinstrap penguins and over 80% of the diet of fur seals throughout the observation period. Fur seals, macaroni penguins and chinstrap penguins all foraged to the north of their breeding colonies on Seal Island at distances ranging from 18-100 km for fur seals, 20-35 km for macaroni penguins, 11-24 km for chinstrap penguins and at depths ranging from 25 m mean maximum dive depth for fur seals, to 43 m and 44 m for macaroni and chinstrap penguins, respectively.

A paper providing more extensive results from the 1989-1990 AMLR cruise will be presented at the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Krill and Ecosystem Monitoring Working Groups in August 1990. (J. Rosenberg, FTS 893- 7600)

COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

COASTAL EASTERN PACIFIC POPULATION BIOLOGY OF FISHES

Oxygen Consumption Rates in Dover Sole

N. Chin Lai (NRC Fellow) reports he has now measured oxygen consumption rates ($\dot{V}O_2$) in 26 Dover sole (*Microstomus pacificus*) ranging in weight from 2.4 to 1110 g. Oxygen consumption rates for the smallest fish amounted to 335 mg O2/kg/h which is 13 times as high as the larger laboratory acclimated fish (26 mg O2/kg/h) and 42 times that of the large wild Dover sole (8 mg O2/kg/h). The allometric exponent (b-value) for fish ranging from 111 to 950 g was 0.83. However, when $\dot{V}O_2$ for all the fish were used (measured at their respective physiological temperature; i.e. range from 3 to 12°C) it yielded a b-value of 0.45.

Such deviation from the traditional b-values (0.6-0.8) is most likely due to the major changes in habitat and physiological conditions that occur over the population's life time of this species (Figure 1).

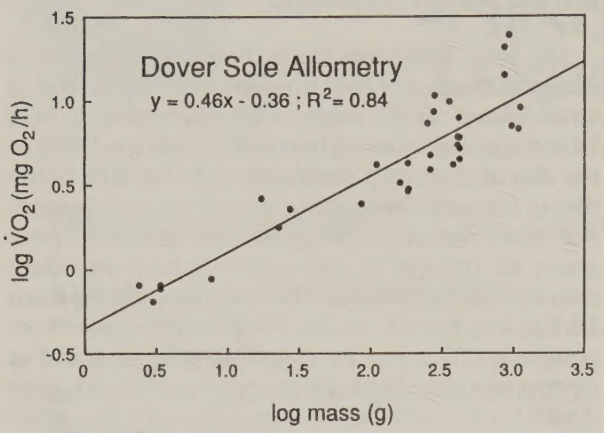

Figure 1. Allometric double log plot of oxygen consumption ($\dot{V}O_2$) for each individual *Microstomus pacificus* (mg O_2/h) versus body wet weight.

On a recent collection cruise aboard the NOAA Ship *David Starr Jordan*, Chin Lai was able to verify previous field measurements of low $\dot{V}O_2$ data (6 to 8 mg O2/kg/h) with fish caught at 300 fathoms. Furthermore, water samples, collected on site where these fish resided, yielded an oxygen concentration of 0.45 ml/l. These two observations, as well as the high water content data in this group of fish, support Hunter's prediction that adult Dover sole living in the oxygen minimum zone have an extremely low energy budget requirement. The next phase of the project will be to determine how this group of fish adapt to live in this cold and hypoxic environment. One possible lead will be to examine the blood-gas properties and hemoglobin compositions between the shallow water juveniles and the deep water adults. (N. Chin Lai, FTS 893-7105)

COASTAL EASTERN PACIFIC FISHERIES ENVIRONMENTAL INVESTIGATIONS

Forecast for 1990 U.S. North Pacific Albacore Fishery Issued

Although favorable ocean conditions could improve prospects, the general outlook for the 1990 U.S. North Pacific albacore fishery predicts modest to moderate landings. The availability of albacore may be highest in waters off the Pacific Northwest, with fish arriving near the latter part of July. In addition to promising commercial fishing, there is high potential for sportfishing off the Columbia River and Grays Harbor areas. The availability of albacore off central and southern California is not expected to be as high as in northern waters. However, at least modest sportfishing in the Southern California Bight is anticipated. The prospects for albacore sportfishing could improve substantially if there is a reasonably successful migration of fish into the Bight from offshore regions. The probability is high for warm-water exotic fish species to be available to sports anglers in the southern California/Baja area due to warm water currents flowing northward along the coast of Baja California. These currents should provide an avenue to bring bigeye and yellowfin tunas, skipjack, dorado and other highly desirable exotic fishes to within reach of boats operating out of southern California as the summer months progress.

There is broad information available on oceanographic conditions over much of the eastern Pacific, and in general, the ocean environment is favorable for albacore. The ocean boundary features east of Hawaii that can play important roles in determining albacore migratory patterns are generally suitable for albacore migration in the eastern Pacific. Likewise, sea surface temperature patterns (SST) over most of the eastern Pacific are favorable for albacore.

During most of the winter, SST's were slightly above normal in a band between about 35°N-45°N, west of 130°W to about 140°W. Along much of the west coast during the last half of April, SST's were about 1°F or less above normal, except off northern Oregon and Washington, and along the coast of Baja California. In the latter areas, SST's were about 2°F above normal. In the region near the coast between Cape Mendocino and Pt. Conception, SST's have alternated between slightly below normal and normal for the past couple months.

Coastal upwelling has been normal or weaker than normal along most of the west coast of the U.S. during the past several months. Moderate, persistent upwelling can set up reasonably good conditions for albacore in waters close to the coast in local areas. However, the strong ocean fronts, with good feeding conditions in the offshore waters, could keep fish several hundreds of miles off the coast in the Pacific Northwest.

Off southern California, the plume of cool, turbid water that flows southward of Pt. Conception should not block the path of fish that may migrate from the west into the Southern California Bight. The plume extends south only to about Ensenada and lies about 200 to 350 miles offshore.

While there is adequate information concerning environmental conditions in the eastern Pacific, the only information available on albacore is from small catches made in mid-April and early May off Baja California. Catches or sightings were made over a reasonably large area extending 50 miles east-west and 25 miles north-south, centered off Cape Colnett. Roughly equal amounts of small 5-6 pound fish and medium 14-16 pound fish were caught, along with some fish weighing up to 20 pounds. Most likely, the fish were not from schools of albacore that immigrated freshly from far offshore waters. The small-sized fish were probably from spawning that occurred by adults that overwintered during 1989-90 in the Guadalupe Island area. The medium-sized fish may be from a body of 9-10 pound fish that was present off southern California late in the 1989 fishing season. This group of fish may have also over-wintered in the Guadalupe Island region.

The early catches were associated with favorable ocean conditions. The fish appeared to follow an avenue of warm water that extended temporarily up the west coast of Baja California from Guadalupe Island. The catches collapsed suddenly when the warm water corridor was choked off by a shift in winds. According to results from tagging studies showing that fish that move into the coastal waters off northern Baja California tend to remain in the Southern California Bight throughout the summer months, it is expected that the body of albacore will reappear and provide catches in the Southern California Bight throughout much of the normal fishing season.

During the past 40+ years, April landings from the Southern California Bight have been made by commercial vessels only in 1947 and 1954. Total U.S. albacore landings made during the 1947 season were well below and during the 1954 season were slightly above the average landings for the 15-year period, 1945-1960.

There is virtually no albacore catch information available at this time from the central or eastern North Pacific. Two U.S. jigboats departed Hawaii in early June to scout for albacore in the central Pacific, but have scouted only a relatively small area and made limited albacore catches. During the decade or so prior to 1988, large vessels would depart from west coast ports in March or April, however, no jigboats have sailed yet this year from the west coast to fish for albacore across the North Pacific. Instead, most of the large jigboats are winding down from fishing for albacore in the South Pacific.

Practically no information is available from the Japanese pole- and-line albacore fishery which operates during spring months in the western Pacific; it is reported that most boats are targeting on skipjack tuna. Neither is their much information on albacore from the Japanese winter longline fishery, which traditionally operates across much of the North Pacific. This fishery is reported to be targeting mostly on bigeye tuna.

Like last year, 3- and 4-year old fish are scarce in the western Pacific, making up only a small proportion of the total low albacore catch. Japanese fishery scientists are concerned that this may be due to the low abundance of these age-classes of fish. These 3- and 4-year old fish also constitute the bulk of the U.S. catch of albacore. If the abundance of these age-classes is low, the U.S. fishery off the Pacific Northwest could also be poor this year.

The NMFS La Jolla Laboratory will issue biweekly albacore fish bulletins beginning July 16 and extending throughout the fishing season. These bulletins, which are mailed to interested fishermen, will provide updated information on albacore catches, migration patterns and general oceanographic conditions. (M. Laurs, FTS 893-7086)

Fishery Oceanography Symposium Set for 1990 CalCOFI Meeting

Ronald Lynn, oceanographer with the Division's Fisheries Environmental Investigations, has organized this year's CalCOFI Symposium for the annual meeting set for October 31-November 2. Nine papers are scheduled. The topic of the nine paper symposium is Fishery Oceanography, a choice which accommodates a wide range of recent and developing applications of oceanography to fisheries problems. In addition, it will cover in-depth observational research projects, computer modeling, new studies and general reviews of physical/biological correlatives, and applications of remote sensing. In a geographical context, these studies extend from the Alaskan Bight to the California Current off Baja California and include one remote sensing application to the availability of codfish off the Grand Banks. In an ichthyological

context, the presentations cover such species as pollack, salmon, rockfish complex, sardine, anchovy and albacore. One presentation examines the distribution of numerically important pelagic and mesopelagic fishes of the California Current system. The contributed papers have been submitted from NOAA laboratories of AFSC (Seattle), SWFSC (La Jolla, Monterey and Tiburon), PMEL, as well as the Naval Post Graduate School, Oregon State University and Scripps Institution of Oceanography. (R. Lynn, FTS 893-7084)

COMMERCIAL AND RECREATIONAL FISHERIES RESEARCH FOR MANAGEMENT

Anchovy Spawning Biomass Estimate

Larry Jacobson presented the preliminary anchovy spawning biomass estimate for 1990 at a meeting of the Anchovy Advisory Subpanel at the Southwest Region, Terminal Island, on June 22. The estimated spawning biomass of anchovy during the middle of February in 1990 was 466,000 metric tons (t) which would result in a quota of 121,000 t for the U.S. reduction fishery during the 1990-1991 season.

Once again, a Stock Synthesis Model was used to produce the estimate using fishery data provided by Walterio Garcia (PESCA), Tom Barnes (LMR) and Terry Dickerson (CDF&G). Estimates include a total of 88,000 t of anchovy landed during 1989: 81,000 t in Mexico and 7,000 t in the U.S. The 1989 age composition and weight-at-age data for anchovy landed in Mexico were, like the data for 1988, atypical. Anchovy were larger than normal during 1989 with one-year-old anchovy recruiting earlier than normal and constituting an unusually large fraction of the catch.

Nancy C.H. Lo provided egg production (MHEP) data and a new index based on aerial survey data that were used in the model. The MHEP for 1990 was 1.85 eggs/0.05 m2/day (SE=0.68), compared to 1.54 eggs/0.05 m2/day (SE=0.55) during 1989. (L. Jacobson, FTS 893-7117)

Amendments to Anchovy Fisheries Management Plan

At the June 22 meeting, the Anchovy Advisory Subpanel discussed comments received from NMFS regarding a proposed definition of overfishing for anchovy that was adopted by the Pacific Fisheries Management Council and forwarded to NMFS/Department of Commerce for review. The reaction by NMFS to the proposed definition was essentially negative and indications are that the Council will have to adopt a definition of overfishing that includes a lower spawning biomass cutoff for all fishing (including live bait fishing). The Advisory Subpanel suggested that a definition with lower cutoff might be acceptable if fishing were restricted only when biomass levels lower than the cutoff were encountered for 2 years in a row. The Anchovy FMP team madeup of Cynthia Thomson, Larry Jacobson and Rick Klingbeil, is in the process of evaluating this possibility. (L. Jacobson, FTS 893-7117)

Status of the California Coastal Pelagic Species in 1989

Cynthia Thomson, industry economist, co-authored an Administrative Report (LJ-90-13) with Cedric Cooney (California Department of Fish and Game) and James Morgan (NMFS Southwest Region) entitled "Status of the California coastal pelagic species in 1989." The report describes management programs, the commercial harvesting and processing sectors, and recreational fisheries as they relate to the coastal pelagic species.

Table 1 describes the species composition of statewide coastal pelagic landings and revenues from 1981 through 1989. Whereas 53% of revenues in 1981-82 were derived from mackerel, this proportion jumped to 81% in 1983-1984 due to the precipitous decline in anchovy landings. Although anchovy landings have remained low, squid landings have rebounded dramatically since 1984. As a result, squid's contribution to total coastal pelagic revenues increased from 3% in 1984 to 41% in 1989, while mackerel's contribution declined from 84% to 49% during the same period. Table 1. California landings and ex-vessel revenues from coastal pelagic species, 1981-1989 and 1984-1988 average.

Statewide coastal pelagic landings in 1989 totaled 104,249 metric tons (t) and had a nominal ex-vessel value of $16.9 million. Total landings in 1989 were 9% higher than 1988 and 40% higher than the 1984-1988 average. The increase from 1988 was due largely to increased landings of mackerel and squid. Real ex-vessel revenues were 10% lower than the 1988 value but 17% higher than the 1984-1988 average.

Approximately 36,129 t of Pacific mackerel, 19,725 t of jack mackerel and 2,609 t of sardine were landed in mixed loads in 1989. Total sardine landings for the year were 3,907 t. This figure includes the incidental take plus directed and dead bait landings of 1,071 t and 227 t, respectively.

Table 1. California landings and ex-vessel revenues from coastal pelagic species, 1981-1989 and 1984-1988 average.

Landings (metric tons)						
Year	Anchovy[1]	Mackerel[2]	Bonito	Squid	Sardine[3]	Total
1981	51,536	51,631	6,453	22,524	--	132,174
1982	42,050	52,983	2,325	16,240	132	113,730
1983	4,300	50,682	3,404	1,816	352	60,554
1984	2,905	52,709	2,802	564	238	599,218
1985	2,009	43,090	2,367	9,308	592	57,366
1986	1,548	52,878	240	21,280	1,188	77,134
1987	1,303	53,475	5,048	19,575	2,095	81,496
1988	1,468	50,188	3,938	36,640	3,785	96,019
1989	2,449	55,924	1,092	40,877	3,907	104,249
1984-88 Average	1,847	50,468	2,879	17,473	1,580	74,247
Nominal revenues ($1000's)						
Year	Anchovy[1]	Mackerel[2]	Bonito	Squid	Sardine[3]	Total
1981	3,181	813	3,912	5,005	--	22,911
1982	2,124	480	1,087	3,590	26	17,307
1983	394	9,633	1,373	754	67	12,220
1984	665	9,531	832	305	43	11,376
1985	417	7,983	504	3,731	110	12,745
1986	274	8,590	83	4,882	215	14,044
1987	239	8,090	2,401	4,340	315	15,385
1988	367	8,082	1,695	7,944	582	18,670
1989	465	8,333	476	7,002	607	16,883
1984-88 Average	392	8,455	1,103	4,240	253	14,444
Real revenues ($1000's)[4]						
Year	Anchovy[1]	Mackerel[2]	Bonito	Squid	Sardine[3]	Total
1981	3,373	11,464	4,148	5,306	--	24,291
1982	2,124	10,480	1,087	3,590	26	17,307
1983	379	9,277	1,322	726	64	11,768
1984	617	8,847	772	283	39	10,558
1985	375	7,181	453	3,356	99	11,464
1986	239	7,502	72	4,264	188	12,265
1987	203	6,885	2,043	3,694	268	13,094
1988	302	6,641	1,393	6,528	478	15,342
1989	364	6,515	372	5,475	475	13,201
1984-88 Average	347	7,411	947	3,625	214	12,545

[1]Includes both reduction and non-reduction landings, but not live bait catch.

[2]The 1981 figure includes total mixed landings of mackerel and sardine. The 1982-89 figures were obtained by subtracting estimated incidental landings of sardine from total mixed mackerel/sardine landings.

[3]The 1982-1985 figures pertain to sardine landed incidentally with mackerel. Because the State of California lifted its moratorium on sardines in 1986, the 1986-1989 numbers include both incidental and directed landings. (Live bait catches not included in any of the figures.)

[4]Deflated by GNP Implicit Price Deflator (Base Year=1982).

Landings of Pacific mackerel in the 1988-89 season totaled 39,370 t, slightly below the previous five-season average of 40,456 t. Landings to date in the 1989-90 season are 20,620 t, the lowest harvests experienced since the 1978-79 season (Table 2). Fishermen complain that the abundance of sardine interferes with mackerel fishing and that sardine are displacing the mackerel from traditional fishing grounds.

Table 2. California landings of Pacific mackerel and northern anchovy (metric tons (t)), by season.

Season	Pacific Mackerel	Northern Anchovy[1]
1978-79	18,960	49,340
1979-80	23,052	34,541
1980-81	27,905	60,681
1981-82	38,184	48,002
1982-83	30,627	5,704
1983-84	36,310	1,680
1984-85	39,241	71
1985-86	37,594	1,371
1986-87	44,298	38
1987-88	44,835	111
1988-89	39,370	234
1989-90[2]	20,620	109

1Reduction only.

2Preliminary.

Anchovy reduction landings in 1989-90 totaled 109 t (Table 2). The ex-vessel price remains low ($36/t) and fishermen continue to divert their effort to higher priced species.

Live bait catches (which are not reflected in Tables 1 and 2) totaled 4,914 t 1989. This figure includes 4,594 t of anchovy, 101 t of sardine, and 219 t of miscellaneous other species. These estimates are based on fishing logs, and may underestimate actual catch because of delinquent logs and because the amount of squid caught directly by commercial passenger fishing vessels for bait is not known.

Information to date in 1990:

1. Some of the sardine fisheries have already closed for the year. The directed fishery closed on January 6 in southern California and on April 25 in northern California. The dead bait fishery, which opened on March 1, closed on March 2 in southern California and on April 10 in central California. Both the dead bait fishery in northern California and the live bait fishery off California remain open at this time.

2. The spawning biomass of northern anchovy in February of 1990 has been preliminarily estimated at 466,000 t. Based on this estimate, the reduction fishery will be open in the 1990-91 season.

3. The preliminary estimate of spawning biomass for Pacific mackerel indicates that fishing will not be limited by a quota in the 1990-91 season. (C. Thomson, FTS 893-7116)

FISHERY-MARINE MAMMAL INTERACTIONS DIVISION

La Jolla, California

Dolphin Survey Design Workshop Held

On July 10-11, 1990, a workshop was held at the Southwest Fisheries Science Center to discuss the survey design for the eastern tropical Pacific (ETP) dolphin monitoring program in 1992 and beyond. Participants reviewed a number of manuscripts prepared by the FMMID staff. Below are brief examples of the topics covered which include the relative abundance estimates from data collected during the 1986-1989 monitoring of porpoise stocks (MOPS) cruises, comparison of NMFS tuna vessel data with MOPS research vessel data, the use of the tuna-vessel observer program simulator (TOPS) model to determine the ability of research and tuna vessels to reflect decreases in dolphin density, and the statistical power analysis of dolphin surveys in the ETP.

Relative Abundance Estimates

The National Marine Fisheries Service has completed four research vessel surveys to monitor trends in the abundance of dolphin stocks that may be adversely affected by purse seine fishing for tunas in the eastern tropical Pacific. Line transect analysis formed the basis for estimating stock- and year-specific abundance indices. Various methods of calculating the stock-specific abundance index have been investigated, including the use of the mean versus the median estimate of school size, the inclusion or the exclusion of small schools; the weighting of

school size estimates; the use of truncated or untruncated sightings data; the use of sightings from all dolphin schools, target schools or a particular species; and the pooling or stratifying of sightings and school size data. The 1986, 1987, and 1988 data were used in the trend analysis, however, it was not surprising that with only three data points, there have been no significant changes in the population index for any of the dolphin stocks. This is so because the power of the trend analysis will only be acceptable after a minimum of six surveys, and even then, the power of the trend analysis will be unacceptable for some stocks because of the limited number of sightings per year. (D. DeMaster, FTS 893-7165)

Comparing Tuna Vessel Data with Research Vessel Data

A comparison between NMFS U.S. tuna vessel (TV) and research vessel (RV) data on dolphins in the ETP was made by Paul Wade, fishery biologist, using school size estimates, encounter rates, the detection probability density function, and abundance estimates. The comparison included only tuna vessel data collected at the same time of the year as the research vessel data (July 28 to December 10). Wade found that the search effort performed by TV crewmen is biased towards schools of dolphins that are likely to carry the most tuna (i.e., large schools of spotted and/or spinner dolphins). There is a selective recording in tuna vessel observer data (TVOD) of these types of schools on a regular basis, due to either a failure to see other types of schools or a failure to communicate sightings of other types of schools to the TV observer. Such selective recording results in low TV encounter rates for striped and common dolphins, and in few data for these species. This bias also results in fewer recordings of the very small (less than 50 animals) spotted and spinner dolphin schools and more recordings of the very large (greater than 1000) schools of these species, relative to research vessels. Again, this conclusion may only apply to the U.S. fleet. Data from the international fleet will be analyzed in the near future.

This under-reporting of small schools of spotted and spinner dolphins apparently keeps TV encounter rates for these species in the same range as RV encounter rates, despite the fact that tuna vessels effectively search a strip more than 50% wider than research vessels. The lack of small spotted and spinner dolphin schools and the high percentage of very large schools in the TVOD causes the mean school sizes from tuna vessel to be more than 2.5 times greater than the mean school sizes from research vessels for these two species. Given the similar encounter rates for spotted dolphins and the lower school density calculated from TV data, differences in published abundance estimates between the two platforms for spotted dolphin are probably driven mostly by the large difference in mean school size. The similarity in abundance estimates between the two platforms for spinner dolphins may be a result of the offsetting differences of a higher TV mean school size versus a wider TV effective strip, as encounter rates are significantly different. The somewhat similar abundance estimates for common dolphins may be a result of the offsetting differences of a higher TV mean school size and narrower TV effective strip versus a lower TV encounter rate. The low TV striped dolphin encounter rate is consistent with the lack of published abundance estimates for this species from tuna vessel data. (P. Wade, FTS 893-7171)

TOPS Model Used to Evaluate Two Types of Dolphin Sampling Methods for Detecting Population Trends

The TOPS computer simulation model, developed by Elizabeth Edwards and Pierre Kleiber, was used by Fishery Biologist Debbie Palka to evaluate sampling and analysis methods of tuna and research vessels'. The model, designed to detect a population decreasing by a constant rate of 10% per year, aimed to determine the vessels' abilities to track a constantly decreasing dolphin population over a period of 6 years, when the spatial distribution of the dolphin schools are density dependent.

While the tuna vessel procedure overestimated the abundance, and that of the research vessel underestimated the abundance, both were able to closely follow the 10% linear decrease.

The estimated abundance of individual dolphins, as calculated from the research vessel's procedure, was not changed by increasing the amount of time spent at each sighting (up to one hour) or by excluding schools with less than 15 animals from the analytical method. The research vessel's procedure was improved by decreasing the amount of time spent at each sighting and by including small schools in the analysis method. Only in the case where small schools were included in the analysis was the estimated school abundance statistically indistinguishable from the actual school abundance; in all other cases, the estimated school abundance was lower than the actual abundance. (D. Palka, FTS 893-7181)

Statistical Power and Detecting Trends in Dolphin Abundance

Tim Gerrodette has completed a power analysis based on the MOPS surveys from 1986-1989. The MOPS surveys were designed using strict controls in order to provide a relative index of abundance and, although the absolute numbers of dolphins might not be known, to measure trends in abundance. Consistent methods and regular surveys allowed a survey design analysis to be conducted which estimated the probabilities of detecting various changes in dolphin populations given different amounts of survey effort. Gerrodette's analysis is based on the power of detecting a regular change in abundance, from research vessel data alone, with unweighted linear regression. His objective was to determine the best survey design for the proposed ETP dolphin surveys after 1991, which would allow researchers to continue building on the information collected since 1986.

Table 1 shows the minimum detectable rates of decrease for various levels of type one and two errors for a study period of 6 years (total of 7 surveys) using either one or two ships. The table also shows the percentage of the original population which would remain after 6 years of decrease at the minimum detectable rate. Even with two ships, the dolphin population could be reduced by more than 50% before a significant decline is measured at the 0.1 significance level. Therefore, the power of detecting declines in ETP dolphin abundance is low without substantial effort. Even at the present survey level, with the effort of two ships and 240 sea days/year, Gerrodette believes that the minimum rate of decrease that can be detectable at the conventional significance level of α=0.05 is 19%/yr.

Gerrodette's calculations show lower sensitivity to trends than previously calculated when MOPS began. The different results can be attributed to four factors. First, MOPS originally planned for 240 sea days of marine mammal sightings. Experience has shown, however, that the effective number of days for marine mammal sightings is somewhat fewer when total available vessel time is 240 days. Second, the sightings rate of dolphin schools/day has been slightly less for 1986-1989 than the rate on which previous calculations were based. Third, the coefficient of variation is based on a total abundance estimate for all dolphins, rather than specifically for spotted dolphins as previously calculated. Finally, the computations made by Gerrodette are based on the t instead of the z distribution, and this results in a further decrease in estimated power. The implication of these results is that a 5-year window for monitoring trends in abundance is inadequate and, rather, a 10 to 15-year time series is needed to detect trends on the order of 5-10% per year. (T. Gerrodette, FTS 893-7131)

Statistical Power and Detectable Trends in Estimates of Dolphin Abundance Derived from Tuna Vessel Observer Data

Two additional ways of analyzing the statistical power of estimated trends in abundance of ETP dolphins were evaluated by Elizabeth Edwards and Cheryl Glick. They first calculated the statistical power for cases where weighted linear regression across 5-year series detected no significant trend (P>0.10). Then, for these same cases, they calculated the amount of change that would have had to exist for detection at a=β=0.10, given observed variability of the data. Due to the relatively large and variable coefficients of variation associated with individual estimates of abundance, power tended to be low in general, but highly variable overall. Power was highest for the group with lowest coefficients of variation.

Table 1. Detectable rates of decrease during a 6-year study period, with either one or two ships and for various levels of statistical error. The percent population remaining is the percentage of the original population remaining at the end of the 6-year study period if the population declined at the minimum detectable annual rate of decrease.

No. of ships	No. of sea days	CV	Error level α=ß	Detectable annual decrease	Percent populaion remaining
1	120	.29	.05	.33	9%
			.10	.19	28%
			.20	.11	51%
2	240	.21	.05	.19	27%
			.10	.13	44%
			.20	.07	63%

Calculations of the trend that would be detectable, given reported CVs and abundance estimates, and assuming $a=\beta=0.10$, showed in general that the large size of the CVs obscured all but very strong trends. Detectable trends ranged from a minimum of 16%/year for northern offshore spotted dolphins to a maximum of 40% for central common dolphins.

The results imply that despite the apparently great density of sightings data in TVOD, trend estimates derived from these data are generally not very precise. The only way to improve both the power of the TVOD estimates and the detectability of trends in abundance is to reduce the variability in annual estimates of abundance, both within and between years. It is not practically possible to increase or otherwise control effort by the tuna fleet. Another avenue would be to reduce variability in estimates derived only from TVOD by some sort of improved stratification of the data. Edwards and Glick have shown that the precision and accuracy of their analysis using TVOD is not appreciably worse than the results to date from the MOPS cruises. MOPS estimates are also characterized by large variance within years, and large changes in abundance estimates between years. In this sense, TVOD and RVOD may be roughly equivalent in terms of usefulness for management, except that the TVOD time series is much larger than the RVOD time series. (E. Edwards, FTS 893-7099)

Preliminary Conclusions

There was consensus among the survey design group members that the core programs for monitoring changes in dolphin abundance should continue for at least another 5-year period. Final minutes for the workshop will be available in September 1990. (D. DeMaster, FTS 893-7165)

COASTAL MARINE MAMMAL PROGRAM

Proposal Submitted for Surveys of Delphinids, Beaked Whales and Other Cetaceans Along the California Coast

In response to the announcement that the NOAA Fisheries Office of Protected Species may have additional funds for the assessment of marine mammals during FY-1991 and FY-1992, the Coastal Marine Mammals Project has submitted a proposal for a series of three aerial line-transect surveys for delphinids and other toothed whales occurring along the California coast. Since it is likely that future management of cetaceans will be based on a percentage quota applied to the minimum abundance estimate, the surveys were designed to yield an abundance estimate whose lower 95% confidence limit is greater than half of the total estimate for each species. This corresponds to a coefficient of variation less than 0.365.

The proposed study was designed with the help of bootstrap procedures performed on ship survey data collected between 1979 and 1984 by the National Marine Fisheries Service. The 5 years of data were treated collectively as a pilot study for future surveys. The survey area was divided into north and south areas at Point Conception, since this is a natural distribution boundary for some of the species of interest. The initial bootstrap procedure, which simulated ship surveys, revealed that the target level of precision could only be obtained for a majority of the species with an excess of 100 days at sea. This was judged to be prohibitively expensive.

Aerial surveys were simulated by using the same bootstrap techniques used for ship surveys, with a few modifications. Most importantly, a random element was included to decide whether each sighting would have been made from the aircraft, accounting for the difference in the probability of sighting animals from the two survey platforms. The simulations showed that approximately 36,000 km of survey effort (16,000 km in the north and 20,000 km in the south) should yield coefficients of variation (CVs) less than 0.365 for common dolphins (*Delphinus delphis*), bottlenose dolphins (*Tursiops truncatus*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), Risso's dolphins (*Grampus griseus*), Dall's porpoise (*Phocoenoides dalli*), and the be aked whales as a group (*Ziphiid* whales). For northern right whale dolphins (*Lissodelphis borealis*) and pilot whales (*Globicephala macrorhynchus*), the CVs are expected to lie between 0.40 and 0.45, while the individual beaked whale species (*Mesoplodon* sp., *Berardius bairdii*, *Ziphius cavirostris*), and other cetaceans are likely to have CV's greater than 0.50.

Information on encounter rates, distribution and seasonality would be obtained for infrequently seen species, such as killer whales (*Orcinus orca*), false killer whales (*Pseudorca crassidens*), striped dolphins (*Stenella coeruleoalba*), sperm whales (*Physeter macrocephalus*), pygmy and

dwarf sperm whales (*Kogia* sp.), fin whales (Balaenoptera *physalus*) and minke whales (*Balaenoptera acutorostrata*).

The proposed line-transect survey calls for two separate sets of transects, covering the north and south areas separately, to be flown with replication in April and October 1991 and in April 1992. In the south, a set of 15 parallel transects covers the Southern California Bight area, approximately out to the 2000 meter depth contour. The transects run northeast to southwest, and would be replicated four times during each survey month. In the north, a set of 46 transect lines zigzag northward between the coast and the 2000 meter depth contour at intervals of 10 minutes of latitude. These transects would be surveyed twice during each survey month. In addition, bimonthly surveys (starting in November 1991) are planned to estimate the abundance of the coastal population of bottlenose dolphins, which are thought to be a distinct stock. These bimonthly surveys would be flown at approximately 0.3 kilometers distance from the coastline between the U.S.-Mexico border and Point Conception.

The survey months, April and October, were chosen to provide the most relevant abundance information. October lies in the middle of the offshore drift-net fishing season. Data from April, 6 months opposed, can provide information on seasonality in the abundance and distribution of cetaceans. Based on previous studies, estimates obtained at these times are thought to be less biased by seasonal migration of animals into or out of the study area than are estimates obtained at other times of the year.

The survey platforms we propose to use are a Twin Otter aircraft for the main surveys, and a Partenavia P-168 for the coastal bottlenose dolphin surveys. Both aircraft have lateral and downward visibility for observers as well as instruments to record exact positions when sightings are made and whenever viewing conditions (weather, sea state, observers, etc.) change. Additional information to be obtained for each sighting includes species, number of animals sighted, and declination angle to the group. The resulting data will be stratified to identify and, if possible, correct for sources of variation in apparent density (weather, season, areas, observers). Abundances will be calculated using line-transect methods. (K. Forney, FTS 893-7171)

HONOLULU LABORATORY

Honolulu, Hawaii

PELAGIC RESOURCES INVESTIGATION

Kewalo Research Facility Hosts International Cooperative Tuna Studies

Scientists from the United States, Canada, and New Zealand gathered at the Honolulu Laboratory's Kewalo Research Facility from May 12 to June 12, 1990, to conduct cooperative studies on skipjack tuna, *Katsuwonus pelamis*, reported Richard Brill, a fishery biologist and the research coordinator. Considered the ocean's most impressive athletes, tuna can use energy and recover from the effects of exhaustive exercise about 10 times faster than any other fish species. This remarkable aspect of tuna biology was the focus of the cooperative research.

The cooperative research examined the physiology of tuna hearts (which are several times larger than those of other fishes); the ability of tuna to recover from exhaustive exercise; and the biochemistry of their skeletal and heart muscles. The benefits of these research efforts include a better understanding of tuna movements, distribution, and abundance and the development of solutions to practical problems such as burnt tuna. (Burnt tuna affects fish intended for raw consumption as sashimi, and costs Hawaii's fishing industry several million dollars annually in lost revenue.)

With a worldwide catch worth in excess of $3 billion annually, tuna form the basis of the largest fishery in not only Hawaii but also the world. The value of tuna caught by local fishermen is almost twice that of all the other commercial fisheries (lobster, bottomfish, and other pelagic species such as billfish) combined.

The scientists participating in the cooperative research were divided into two groups. The group performing the physiology studies was headed by Anthony Farrell (Department of Biology, Simon Fraser University, Vancouver, British Columbia). The biochemistry group was headed by Peter Hochachka, (Department of Zoology, University of British Columbia, Vancouver, British Columbia).

Farrell's group examined what tuna hearts can and cannot do and how important blood circula-

tion is in the heart muscle itself. Some studies involved leaving the heart in situ while isolating it from the remainder of the fish's circulatory system and perfusing the heart with a buffered saline solution. This unusual technique, developed for fish by Farrell, allows scientists to control a fish's arterial and venous blood pressures while simultaneously monitoring how its heart responds when blood pressures are increased or decreased. Based on their preliminary results, tuna hearts more closely resemble mammalian hearts than those of other fishes.

Farrell's group also tried to determine the normal cardiac output of tuna and what mechanisms control the heart muscle's contractions. Examining the role of free intracellular calcium at the biochemical level in promoting heart contractions, Glen Tibbits of the Department of Kinesiology, Simon Fraser University hoped to help explain why tuna hearts behave physiologically in ways more similar to mammalian hearts than to those of other fish species.

Hochachka's group concentrated on investigating how tuna are able to recover from strenuous exercise so quickly. Compared with trout, which take 12 to 14 hours to recover from exercise, tuna are about 10 times faster and may be as fast as human beings, according to Peter Arthur, a postdoctoral fellow with the Department of Zoology, University of British Columbia. To gain insight into how tuna replenish their energy so quickly after exhaustive exercise, Hochachka's group measured glycogen, lactate, and other biochemical indicators. Glycogen is stored in the muscles and, during exercise, is metabolized to lactate in white muscle. When glycogen is depleted and lactate builds up, fish must "refuel" with more glycogen. Tuna apparently are able to refuel very rapidly, whereas other fish species are thought to be slow refuelers.

Besides studying the biochemistry of the skeletal and heart muscles, the scientists also examined the relative ability of skeletal muscle, cardiac muscle, and liver to aid tuna in recovery after severe exercise. In one study, scientists isolated groups of tuna liver cells for study. This organ is believed to play a major role in resynthesizing glycogen after exhaustive exercise.

Tuna for the studies were supplied by Sadami Tsue, captain of the fishing vessel *Corsair*, which docks at Kewalo Basin. Tsue has been supplying the Honolulu Laboratory's Kewalo Research Facility with fish for scientific study for the past 17 years.

The Kewalo Research Facility is the only laboratory in the world where tuna are maintained in shoreside tanks and are available live for research. The facility has had an active tuna research program for almost 30 years and regularly hosts visiting scientists from around the world. It also serves as a live animal holding facility for Honolulu Laboratory scientists and has been the site of important research on everything from endangered species (Hawaiian monk seals, *Monachus schauinslandi*, and green turtles, *Chelonia mydas*) to lobster and bottomfish.

Other scientists who participated in the cooperative studies on tuna included Tim West, Les Buck, and Chris Moyes, graduate students of Hochachka's; Peter Davie and Craig Franklin of the Department of Physiology and Anatomy, Massey University, Palmerston North, New Zealand; John Keen, Farrell's graduate student; Jeff Johansen, Farrell's research assistant; Haruyo Kashihara, Glen Tibbits's research assistant; and Odile Mathieu-Costello, Department of Medicine, University of California, San Diego. (R. Brill (808) 943-1234)

Brill Presents Lecture at International Conference

Fishery Biologist Richard Brill attended the 29th Annual Conference of the Canadian Society of Zoologists held at Simon Fraser University, Vancouver, British Columbia, on May 2-5, 1990. During the Conference's Cardiac Scope in Lower Vertebrates Symposium, Brill presented an invited lecture, "Metabolic and cardiac scope of high energy demand teleosts--the tunas." His talk described features of the cardiovascular system of tunas that account for their ability to have maximum levels of oxygen uptake far above those of most other fishes. A manuscript based on the talk will be published as part of the symposium proceedings in the Canadian Journal of Zoology. (R. Brill (808) 943-1234)

INSULAR RESOURCES INVESTIGATION

Overfishing Measured and Applied to Hawaii's Bottomfishes

A study of a proposed definition of overfishing and its applicability to Hawaiian bottomfishes was recently completed by David Somerton, leader of

the Insular Stock Assessment Program, and Donald Kobayashi, fishery biologist. Their study was prompted by recent actions of the Western Pacific Regional Fishery Management Council's Plan Monitoring Team to amend the Bottomfish and Seamount Groundfish Fishery Management Plan to include an objective and measurable definition of recruitment overfishing that is consistent with the revised "Guidelines to Fishery Management Plans" (50 CRF Part 602).

The definition proposed by the team is that a bottomfish species is overfished when the spawning potential ratio (SPR), or the ratio of the spawning stock biomass per recruit at the current level of fishing (SSBRf) to the spawning stock biomass per recruit that would occur in the absence of fishing (SSBRu), is ≤0.20.

To determine whether this definition could be successfully applied to Hawaii's bottomfishes by using extant data, values of SPR were calculated for each of the five principal bottomfish species: opakapaka, *Pristipomoides filamentosus*; onaga, *Etelis coruscans*; ehu, *Etelis carbunculus*; uku, *Aprion virescens*; and ulua, *Caranx ignobilis*.

Two estimators of SPR were examined, an equilibrium estimator and a dynamic estimator. The equilibrium estimator of SPR is based on a yield-per-recruit theory and assumes that the rate of fishing and the size range of fish that are harvested have remained or will remain constant long enough for the population to be considered in equilibrium. Values of equilibrium SPR require estimates of fishing mortality (F), natural mortality (M), the rate constant (K) and asymptote (L_∞) of the von Bertalanffy growth equation, length at entry into the fishery (l_e), and the length at maturity (l_m).

Estimates of F/K, M/K, and L_∞ were obtained for each species using the Wetherall method, a length-based procedure, to analyze catch length-frequency data derived from sales receipts obtained by NMFS personnel at the Honolulu fish auction during 1986-1988. First, Z/K and L_∞ were estimated by applying the Wetherall method to data from the main Hawaiian Islands (MHI), an area that has received heavy fishing pressure. Then M/K and L_∞ were estimated by applying the method to data from the Northwestern Hawaiian Islands (NWHI), an area that has received light fishing pressure. A value of F/K was estimated as the difference of Z/K and M/K; L_∞ was estimated as the average of the MHI and NWHI estimates.

The dynamic estimator of SPR is based on the change in the catch per unit effort (CPUE) of mature fish relative to that at the initiation of the fishery and is a direct estimate of the relative spawning biomass rather than a theoretical approximation of its value at population equilibrium. Algebraically, this estimator is expressed as $(Uf\ Pf)/(Uu\ Pu)$, where Uf and Uu are the current (fished) and initial (unfished) CPUE and Pf and Pu are the current and initial population correction coefficients. Values of P were calculated as Pm/Ps, where Pm is the proportion, by weight, of the catch composed of mature fish and Ps is the proportion of mature fish selected by the fishery as determined using a linear selection function. Values of Uf and Uu were estimated from the daily catch reports submitted by fishermen for 1986-88 and 1947-49 to the Hawaii Department of Land and Natural Resources.

Values of equilibrium SPR could be calculated for only two of the five species (Table 1). The reasons for this varied. For uku, length-frequency samples from the NWHI were too few to obtain Wetherall estimates of M/K. For ulua, selectivity by the fishery for small sizes in the MHI resulted in unrepresentative size-frequency distributions. For onaga, estimates of Z/K, M/K, or L_∞ appeared to be biased because of violations of either the equilibrium or the size-selection assumptions of the Wetherall method. By comparison, values of dynamic SPR could be calculated for all five species of bottomfish (Table 1). These estimates, however, are probably biased for at least two reasons: (1) the change in CPUE that has occurred over the 40 years (1947-88) was not corrected for increases in fishing power due to the use of chromoscopes and power reels, and (2) aggregate CPUE may not be a good measure of the relative abundance of individual species.

Table 1.--Estimates of equilibrium and dynamic spawning potential ratio (SPR).

Species	Equilibrium SPR	Dynamic SPR
Opakapaka	0.31	0.29
Onaga	--	0.25
Ehu	0.21	0.30
Uku	--	0.40
Ulua	--	0.25

Based solely on the criterion that a species is overfished when SPR<0.20, we conclude that none of the species is presently experiencing recruitment

overfishing (Table 1). However, considering that (1) there is a large uncertainty in the estimates of SPR and (2) four of the five species had dynamic SPR values <0.30, it would be prudent to consider some form of management that is likely to increase the spawning biomass. (D. Somerton (808) 943-1259)

FISHERY MANAGEMENT RESEARCH PROGRAM

1990 Swordfish Landings

Kurt Kawamoto, fishery biologist, and Russell Ito, biological technician, completed a brief summary of the activities in the swordfish, *Xiphias gladius*, fishery so far in 1990. As of May, 46 longline fishing vessels made 128 trips and landed 1.3 million lbs of swordfish. This almost tripled the total landings for 1989, which was a 10-fold increase from 1988. The average trip length in 1990 has been six fishing days (range, 4-14 days), with running days (range, 1-5 days) depending on the fishing location. The average number of hooks set has been 900 (range, 300-1,300 hooks) per night, with lightsticks deployed in a range from every hook to every fourth hook. The preferred bait was large squid.

The average catch of swordfish per trip was 9,200 lbs. Species composition was 60% swordfish, 30% tunas, and 10% other pelagics. Most of the fishing occurred north of the main Hawaiian Islands. The number of participants has increased throughout the year, particularly as the tuna longline catch of bigeye tuna, *Thunnus obesus*, declined seasonally, and the catch of lower valued species (i.e., striped marlin, *Tetrapturus audax*, and albacore, *Thunnus alalunga*) increased. (S. Pooley (808) 943- 1216)

Council Meetings

A meeting of the Western Pacific Regional Fishery Management Council was held June 18-20, 1990, which focused mainly on 1) the definitions of overfishing for each of the four fishery management plan fisheries (pelagic fishes, bottomfishes and groundfishes, crustaceans, and corals), and 2) the consideration of an effort limitation in the lobster and longline fisheries. The same material was previewed by the Council's Scientific Statistical Committee on June 14-15.

The Council's Pelagic, Bottomfish and Seamount Groundfish Fishery Plan Monitoring Teams met May 7-18 at the Honolulu Laboratory for the annual review of the fisheries. At the meeting, Biological Technician Russell Ito reported that Hawaii's longline fishery landings increased by 94% in 1989, while the troll and handline pelagic fisheries declined by 33%, based on the Fishery Management Research Program's market monitoring program. Total longline landings equaled 5.9 million lbs for tuna and 3.6 million lbs for pelagic management unit species (mahimahi, *Coryphaena hippurus*; ono (wahoo), *Acanthocybium solandri*; billfishes; and sharks). Troll and handline landings totaled 1.8 million lbs for tuna and 1.6 million lbs for pelagic management unit species. Troll landings of yellowfin tuna, *Thunnus albacares*, were particularly poor in 1989. The total value of the pelagic fishery in 1989 was $31.2 million. At the same meeting, Fishery Biologist Kurt Kawamoto reported that the bottomfish fleet in the Northwestern Hawaiian Islands continued to decline, with only eight vessels active in 1989. Landings of bottomfish management unit species in 1989 totaled 303,000 lbs ($756,000), down 52% from 1988 and 70% from 1987. Landings of bottomfish in the MHI in 1989 equaled 1.2 million lbs ($3.9 million), down 25% from 1988. Foreign imports of snappers, groupers, and jacks now constitute 26% of Hawaii's market. (S. Pooley (808) 943-1216)

PACIFIC FISHERIES ENVIRONMENTAL GROUP

Monterey, California

PHYSICAL OCEANOGRAPHY

Surface Marine Weather Climatic Data Base Completed for Eastern Pacific Ocean

An extract of the Global Comprehensive Ocean-Atmosphere Data Set (COADS), obtained from the National Center for Atmospheric Research, has been completed for the eastern Pacific Ocean region (0-60°N) in a 32-bit word format compatible with the PFEG computer network. These data consist of historical surface weather observations, primarily from merchant vessels, collected over the period from 1854 to 1986. Packed binary files were created for each 10-degree latitude-longitude area (Marsden square) and the individual reports within each 1-degree latitude-longitude subsquare are sorted chronologically to facilitate time series analysis.

The individual reports contain the date (to the hour), latitude, longitude, air temperature, sea surface temperature, north and east wind component

of wind velocity, wind speed, barometric pressure, dewpoint depression, and total cloud amount. These data files provide an important resource for ongoing research on air-sea energy transfer processes and exploratory data analyses on global climate change. (D. Husby (408) 646-3311)

Groundfish Recruitment-Oceanography Survey Data

Tiburon Laboratory scientists have made over 1800 CTD casts off central California since 1987, as part of the rockfish recruitment survey program. PFEG oceanographers are presently summarizing the hydrographic information from these cruises in a series of horizontal surface maps and vertical sections. These products include maps of temperature, salinity and density on 5, 30, 50, 100 and 200 m surfaces, and for five sections extending across the continental shelf and slope between Cypress Point and Pt. Reyes. Additional specialized maps are being generated, including maps of the mixed layer depth, the depth of certain isothermal and isopycnal surfaces, and the temperature and salinity on those surfaces.

Mapping of the data from two of the Tiburon cruises on the *David Starr Jordan* is completed (Cruises 8804, April 16-22, 1988 and 8904, May 14-June 13, 1989). These products have been forwarded to the Tiburon Groundfish Analysis Task to assist them in their analysis of trawl data collected at the time of the CTD casts. NOAA Technical Memoranda are now being prepared for each cruise in collaboration with Tiburon personnel, and are expected to be available in the fall of 1990. Other scientists interested in obtaining copies of any of these hydrographic maps should contact Frank Schwing (408 646-3311) for further information.

In addition, hydrographic observations from these surveys are being analyzed in detail by PFEG scientists, who are also collaborating with other physical oceanographers conducting concurrent field studies in the region. Preliminary results suggest considerable hydrographic variability on relatively small time and space scales. Such variability may be coupled to recruitment success on similar scales. Some of these results will be presented at the Fisheries Oceanography Symposium, to be held at the upcoming CalCOFI meeting.

The manuscript "The Weddell-Scotia confluence in mid-winter" by Robin D. Muench, John T. Gunn, and David M. Husby has been accepted for publication in the Journal of Geophysical Research. This manuscript describes the oceanographic conditions observed in the Weddell-Scotia Confluence region in the southern central Scotia Sea during the June-August (austral winter) 1988 field survey of the Antarctic Marine Ecosystem Research at the Ice Edge Zone (AMERIEZ) program. The data substantiate past accounts of the region, based on summer field research, as being dominated by eastward flow upon which is superimposed a complex array of mesoscale features. The region was characterized by intense mixing activity and primarily anticyclonic flow structures. Two warm core eddies or meanders dominated the flow field; these eddy-like features had horizontal dimensions on order 100 km and were imbedded within the eastward flow. No evidence was found of deep convective mixing which has been hypothesized, from past summer data, to occur in winter.

The goals of the AMERIEZ field program are to investigate whether the ice edge is an important ecological interface between distinct biological communities and whether the marginal ice zone is an oceanographic front where productivity is enhanced. The physical oceanographic component of the AMERIEZ program will be summarized in a forthcoming paper in the Proceedings of the 22nd Liege Colloquium on Ocean Hydrodynamics: Ice-covered Seas and Ice Edges, May 1990. (D. Husby (408) 646-3311)

PELAGIC FISHERIES RESOURCES DIVISION

La Jolla, California

MULTISPECIES DATA COLLECTION AND EVALUATION PROGRAM

Dolphin Mortality in U.S. Tuna Fishery Declines in 1989

In 1989, NMFS observers were on-board tuna vessels for 75 fishing trips resulting in a total of 2,204 sets on dolphins. The data collected on these trips were verified by Randy Rasmussen and Mike Trianni, biological technicians, and are maintained by the Multispecies Data Collection and Evaluation Program. (Data for an additional 48 trips were collected by IATTC observers, but were not available for this article.) The data were also presented at a poster session of the 41st Annual Tuna Conference held at Lake Arrowhead, California, May, 1990, by Alan Jackson, fishery biologist.

The geographic distribution of the observed dolphin sets is given in Figure 1. Although dolphin sets were observed as far as 148°W and as far as 12°S, the majority of the sets occurred in three general areas: 10-13°N and 90-95°W; 10-15°N and 100-110°W; and 7-11°N and 124-138°W. The average tuna catch per dolphin set in 1989 was 18.9 st, up from the 1988 rate of 17.1 st. Average tuna catch rates for dolphin sets from 1976 to 1989 are given in Figure 2.

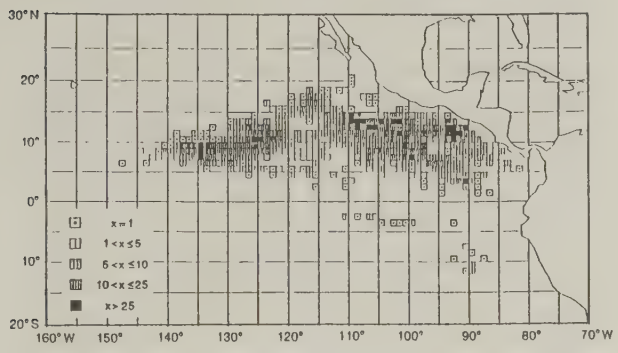

Figure 1. The number of dolphin sets, by 1° quadrants, made by U.S. tuna purse seiners carrying NMFS observers in 1989.

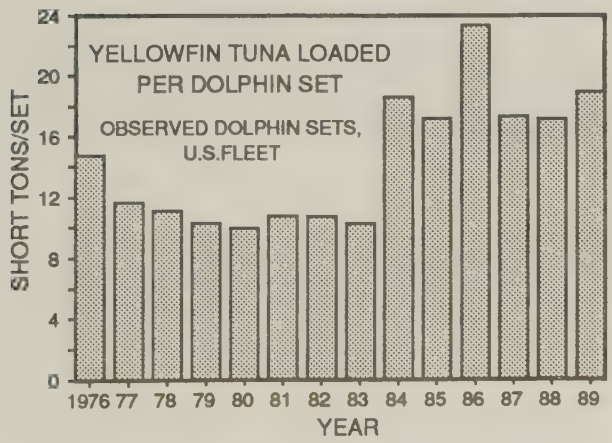

Figure 2. The average catch of yellowfin tuna per observed set on dolphins by U.S. tuna purse seiners, by year, for 1976 to 1989.

The estimated number of dolphins killed in the U.S. tuna purse seine fishery in 1989 was 12,643, down 36% from the estimated 1988 kill of 19,712, according to data collected by on-board observers from the National Marine Fisheries Service and the Inter-American Tropical Tuna Commission. The 1989 dolphin kill was well below the allowable annual quota of 20,500, and was the lowest recorded for the U.S. fleet since 1983, when an estimated 9,589 dolphins were killed.

An area of low dolphin kill-per-ton rates (the number of dolphins killed per ton of tuna caught) in 1989 tended to be centered on 10°N and 100°W (Figure 3). Areas of higher dolphin kill rates were located along the western and southern peripheries of the fishing grounds and within 300 miles of the coastline between 7-15°N.

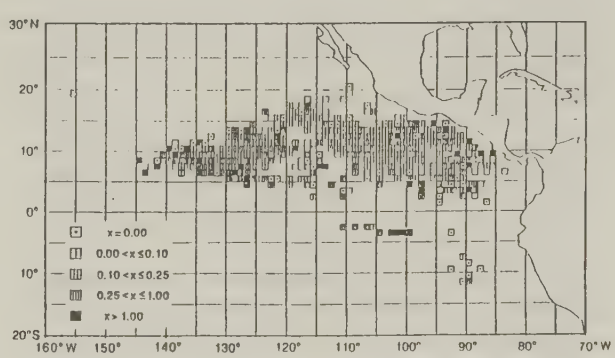

Figure 3. The dolphin kill-per-ton rates, by 1° quadrants, for U.S. tuna purse seiners carrying NMFS observers in 1989.

The observed dolphin kill-per-ton rate in 1989 was 0.20 dolphin, down 35% from the 1988 rate of 0.31 dolphin (Figure 4). The dolphin kill-per-set rate in 1989 was 3.7 dolphins, down 30% from the 1988 rate of 5.3 dolphins (Figure 5). After achieving tremendous improvements in dolphin kill-per-ton

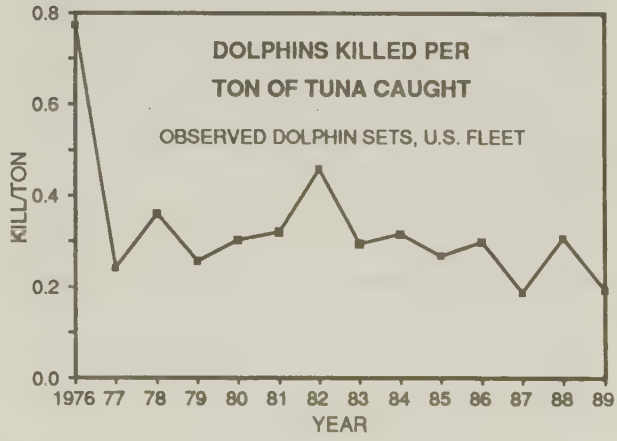

Figure 4. The average dolphin kill-per-ton rates for observed U.S. tuna purse seiners in the eastern tropical Pacific Ocean from 1976 to 1989.

and kill-per-set rates in 1977, the fleet performance has remained relatively constant for the past 13 years.

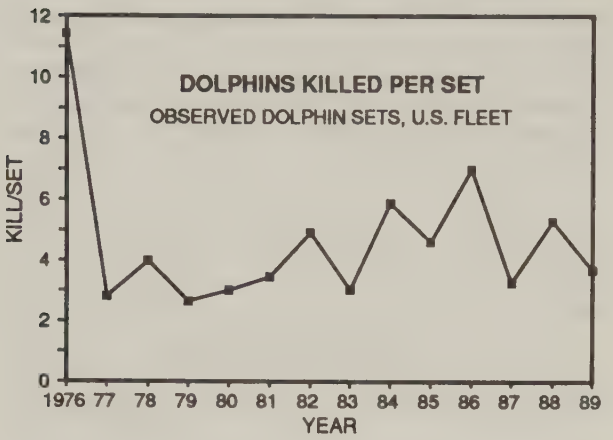

Figure 5. The dolphin kill-per-ton rates for observed U.S. tuna purse seiners in the eastern tropical Pacific Ocean from 1976 to 1989.

(A. Jackson, FTS 893-7048)

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

High Seas Driftnet Impact Assessment

The Stock Assessment and Fishery Impact Analysis Program is receiving good results from the two observers placed on-board the Western Fishboat Owners Association's chartered albacore scout boats. Because there are serious concerns that the driftnet fisheries in the north Pacific are adversely affecting the albacore stock in the U.S. troll fishery, these observers were placed aboard the U.S. albacore jig boats F/V *Royal Dawn* and the F/V *Mercator* to assess the direct impact on survival of albacore that encounter high seas driftnets.

Albacore that survive an encounter will bear some external mark that identifies it in the troll catch, so the percentage of gillnet marked fish can be estimated. Observers monitor the ratio of gillnet marked albacore to those not marked. Marked fish presumably face an increased risk of death due to injuries sustained during the encounter.

The first two albacore observers left Honolulu on May 29 and proceeded north to the international date line where they found only a few small fish. By the end of June, the vessels moved east to the area around 36°N and 160°W. They reported low to moderate catches in the 30 to 100 fish per day range. These fish were 8 to 9 kg with about 20 percent showing some sign of having encountered a gillnet.

Three more observer trips are scheduled to depart for the offshore fishing grounds in July, and four coastal trips are scheduled for August and September. (D. Holts, FTS 893-7186)

Gardiner Foundation Billfish Tagging Awards for 1989

The winners of the Gardiner Foundation awards program for the most billfish tagged by Mexican charterboat captains fishing the southern tip of Baja California have been determined from the SWFSC billfish tagging program records. The first place winner was Captain Gilberto Castro Collins who recorded 57 billfish tagged and released. Awards of cash and a plaque are given to the six leading captains, whose names and numbers of billfish tagged are: Captain Victor Garcilia (54), Captain Antonio Vargas (50), Captain Jesus Ariza (43), Captain Martin Verdugo (39), and Captain Tomas Yepiz (34). About 35 charterboat captains participated, and the winners are all from the east Cape area of Baja California.

The Gardiner Foundation of Oakland, CA has provided cash and award plaques since 1970 to encourage the captains to tag billfish, thereby assisting the SWFSC program in determining the migration patterns and rates of migration of billfish in the northeastern Pacific. (J. Squire, FTS 893-7072)

TIBURON LABORATORY

Tiburon, California

Pre-fishery Stock Sizes Estimated for Two Southern California Fishes

Alec MacCall, acting director Tiburon Laboratory, and Timothy Ragen, a doctoral student at UCSD Scripps Institution of Oceanography, completed a California Sea Grant project titled "Pre-fishery abundances of important large recreational and commercial fishes off southern California." The estimates are based on historical commercial catches and records of the largest yellowtail (*Seriola lalandei*) and white seabass (*Atractoscion nobilis*) caught by the Avalon Tuna Club each year since 1898. A three-parameter (initial population size,

natural mortality rate, and a sample size coefficient) simulation model produces an estimated size composition of the stock for each year. Those size compositions provide probability distributions for the largest fish each year, allowing values of the parameters to be estimated by the method of maximum likelihood. The simulation model was so complicated, and the number of simulations needed to search the likelihood response surface was so large that the project could not have been undertaken without the use of the SDSC Cray Supercomputer.

The estimated likelihood response surfaces are shown in Figure 1. The surfaces have a discontinuity in the upper left side of each plot. These areas represent cases where there is insufficient initial abundance to support historical harvests. The initial abundances

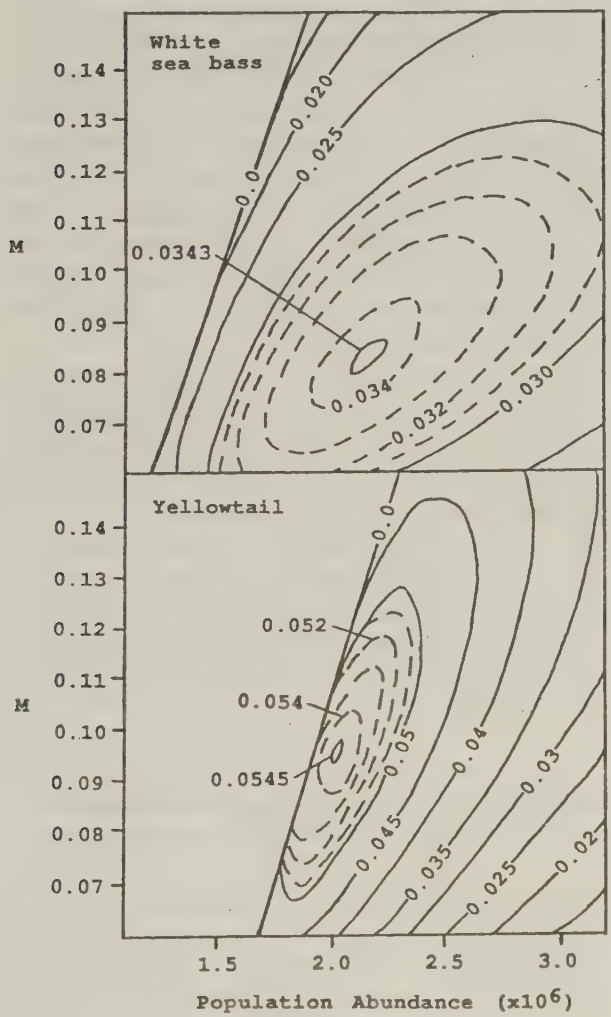

Figure 1. Likelihood of surfaces for combinations of natural mortality rate (M) and initial abundance.

of yellowtail and white seabass resident in southern California each appear to have been about 20,000 tons (estimated CV's 5-12%, and 25-40%, respectively). This approach is unusual among fishery models in that natural mortality rate (M) is estimated rather than assumed. Estimated M for yellowtail was 0.10 and for white seabass was 0.08 (both CV's about 15%).

These results could influence management of these popular species, as well as influence current studies toward enhancement of the white seabass resource by artificial propagation. Both fish stocks presently migrate seasonally to southern California from Mexican waters, and fishery management has been consistent with this resource behavior. This study suggests that resident stocks once existed, and were fished out circa 1920. Management based on conservation of resident stocks would require much greater restrictions on fishing effort, but improved benefits could result once those stocks were re-established. Indeed, the recent interest in artificial propagation of white seabass would seem to be more consistent with management of a resident rather than migratory resource. (A. MacCall, FTS 556-0565)

GROUNDFISH COMMUNITIES INVESTIGATION

Increases in Benthic Algae Transform Near Shore Environment

There has been greatly increased growth of low-lying algae close to shore along the Mendocino coast during the past year. With the perennial *Pterygophora californica* predominating, these plants have dramatically transformed a site near Albion that has been under study by the Groundfish Communities Investigation since 1981 (Figure 2). This growth also seems to have altered a pattern of change defined earlier by Fishery Biologists Ted Hobson, Tony Chess and Dan Howard and described in the Bimonthly Report of Activities of November-December 1988. The report emphasized how areas forested by the bull kelp, *Nereocystis leutkeana*, had expanded each year since the sea urchin fishery became established there in 1985. This year, however, that pattern has changed.

The beds of bull kelp, which are an annual, are largely swept away by stormy seas each winter, and must become reestablished in the spring. Each spring since 1986, the year after fishing for sea urchins began at this site, the bed that developed was larger than the bed of the year before. But it

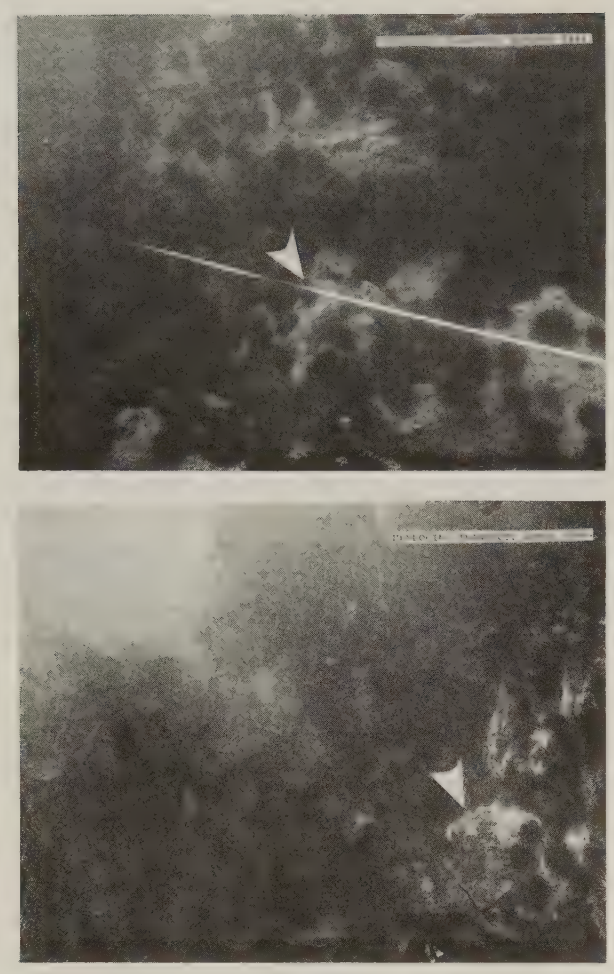

Figure 2. Recent proliferation of low-lying brown algae and reduced number of sea urchins at the Mendocino study site. Two views of the same location: a) October 1981, b) April 1990.

has become obvious that there is less bull kelp this year than last, at least at this site. Perhaps this is because many of this year's bull-kelp sporophytes settled in the shade of what has become a dense understory of low-growing algae. Presumably, the species forming this understory, like the bull kelp, have proliferated with the removal of grazing pressures from urchins, but it remains uncertain why it took them longer than it did the bull kelp to respond to this removal. (E. Hobson and J. Chess, FTS 556-0568)

GROUNDFISH ANALYSIS INVESTIGATION

1990 Pelagic Juvenile Rockfish Survey Completed

The annual May-June cruise aboard the NOAA Ship *David Starr Jordan* was successfully completed. As in years past, the objective of this cruise was to survey the distribution and abundance of young-of-the-year pelagic juvenile rockfish (*Sebastes* spp.) off the central California coast from Cypress Point north to Bodega Bay. Sampling for the juveniles was conducted in midwater at night using a modified Cobb Trawl; a series of standard stations were repetitively sampled over the 30- day duration of the cruise. The data collected provide information on interannual and within season fluctuations in juvenile abundance. During the day the vessel conducted CTD casts in the area to develop a better understanding of the physical environment inhabited by the fish.

Results from this year's survey (Table 1) show that average catches of most species were moderate to poor. As in years past, shortbelly rockfish (*S. jordani*) was most numerous, accounting for approximately 80% of all juveniles caught. Also, with the exception of yellowtail rockfish (*S. flavidus*), there was a definite decline in the numbers of fish caught as the cruise progressed. Data collected in April, however, indicate that, except for chilipepper (*S. goodei*), numbers were quite low at that time.

Table 1. Catch rates of selected pelagic juvenile rockfish (*Sebastes* spp.) taken at standard stations off the central California coast during 1990. Numbers represent the stratified mean number of individuals captured during a 15-minute midwater trawl (N=33) at standard depth.

	Rockfish species				
Sampling	Shortbelly	Bocaccio	Chilipepper	Widow	Yellowtail
April 1	2.01	0.02	1.52	0.00	0.14
May 18	124.54	1.03	1.48	7.89	0.20
May 28	3.23	0.27	0.43	0.44	0.67
June 7	0.64	0.00	0.00	0.11	0.09

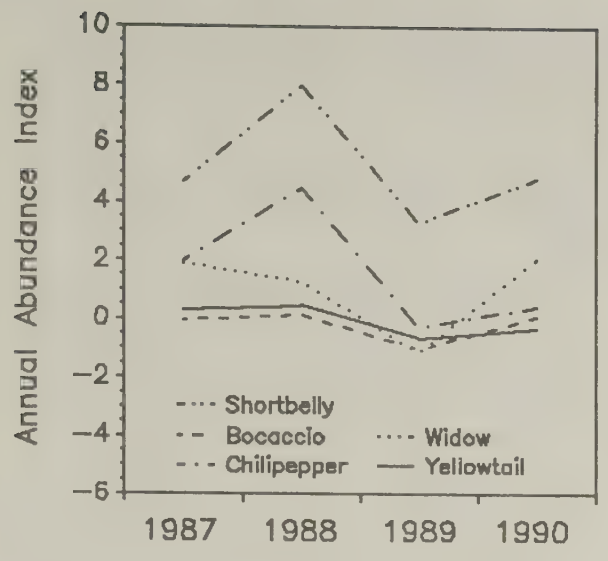

Figure 3. Interannual variation in an index of abundance of five species of pelagic juvenile rockfish.

A comparison with data from the May-June surveys of previous years (Figure 3) reveals the extent of interannual variation shown in these surveys. Our findings indicate that in 1988, pelagic juvenile rockfish were relatively abundant, whereas in 1989 they were quite scarce. In the near future, it will be possible to relate the abundance of these rockfish species as young-of-the-year juveniles to their projected year class strength at the time each cohort enters the commercial fishery (ages II-V, depending on the species).

One problem we have encountered in these surveys, which was particularly evident this year, is the occurrence of an unusually large number of juveniles in a single haul. For example, for the cruise as a whole, the average catch rate of pelagic juvenile rockfish was on the order of 10 fish per standard haul. However, one station outside of Monterey Bay that was occupied during the first sweep produced in excess of 5,200 juvenile Sebastes. The next largest number of juveniles taken in any trawl during the cruise was only 57 fish. Extraordinary catches such as this one make statistical inferences quite difficult, yet results like these are commonplace in trawl studies. To help circumvent this problem, we are currently exploring alternative statistical techniques, including trimming the mean, outlier detection, and the use or order statistics. (S. Ralston, FTS 556-0565)

INFORMATION TECHNOLOGY SERVICES

WordPerfect Training Held

In fulfilling its charter as a service unit and in an effort to ease the transition from WordStar to the new NOAA mandated wordprocessor, ITS compiled and offered formal WordPerfect training sessions. The sessions were condensed and topically oriented for the convenience and ease of the user. Three classes each for beginning, intermediate, and advanced levels were offered.

ITS assessed how the lesson plans could be tailored to provide La Jolla users with a quick reference guide on common procedures and procedures unique to their needs. This training is currently available for informal training sessions in the ITS Training Center's library of self-paced tools.

To provide further WordPerfect help to the staff, ITS has recommendations for off-premises training suitable for advanced and specific needs. (S. Jacobson, FTS 893-7060)

PUBLICATIONS

Published

Cohen, Daniel M., Richard H. Rosenblatt and H. Geoffrey Moser. 1990. Biology and description of a bythitid fish from deep-sea thermal vents in the tropical eastern Pacific. Deep-Sea Res. 37(2):267-283.

A new fish species of the world-wide genus *Bythites* (Bythitidae, Ophidiiformes) is based on a gravid female captured in a thermal vent in the Galapagos Rift Zone. No apparent morphological features of adults or larvae account for life in the vent environment. Gill arch structure does not indicate filter feeding. The few fish species living in vents are not representative of ancient groups and are probably recent arrivals. The species is intermediate between the nominal genera *Bythites* and *Abythites*; hence, the latter is considered a junior synonym. The new species differs from its four congeners in its high dorsal, anal, and pectoral fin ray counts and its broad interorbital space. Free sperm and spermozeugmata are present throughout the ovarian tissue. Intraovarian larvae have a well- developed yolk sac, large oil globule, and pigmented eyes. Brood size is about 10,000.

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Withholding food for 4 weeks resulted in more extensive alterations within serum lipoprotein classes in striped bass (*Morone saxatilis*) than were evident in serum total lipids where only a decrease in triglycerides was significant. Total serum lipoprotein concentrations were about 3300 mg/dL in both fed and starved fish; however, high density lipoproteins (HDL) increased and very low density lipoproteins (VLDL) decreased significantly in the starved group. Quantitatively, the greatest changes in VLDL, the primary transporter of triglycerides, were declines in triglycerides and cholesterol esters. Within low density lipoproteins, triglycerides and phospholipids decreased. The HDL composition was affected least by starvation. Phospholipids were the dominant lipid in HDL and increased from 479.1 mg/dL in fed fish to 670.2 mg/dL in starved fish. The apoproteins of each lipoprotein class changed little qualitatively due to starvation. Our results reflect the importance of maintaining high levels of lipoproteins as a transport system for lipids from storage depots to depleted tissues permitting survival during prolonged periods of starvation that are often encountered by fish during colder months and during spawning migrations. Furthermore, during starvation HDL appears to assume increased significance as a vehicle for the transport of structural lipids to maintain tissue integrity.

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The purpose of this application is to conserve the specific name of the pantropical spotted dolphin, *Stenella attenuata* (Gray, 1846), the type species of *Stenella* Gray, 1866. The specific name is threatened by three subjective synonyms, only one of which has been mentioned (as a probable synonym) during this century.

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This paper considers capacity utilization measures for the multi- product firm. The single-product dual measure of capacity utilization easily extends to the multi-product case. Three possible extensions of the single-product primal measure are considered. Although each has its limitations because of the restrictions embodied in it, each provides different, yet potentially useful information about capacity utilization in a multi-product industry. The dual and primal measures of multi- product capacity utilization are applied to the multi-species New England fishing industry to evaluate the potential for capacity expansion under a regulatory program of license limitation.

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